MINE MAP INTERPRETATION

Presented By

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INTRODUCTION

During the Quecreek mine rescue operations, the initial media reports kept referring to a mine crew trapped in a mine shaft in Somerset County PA. It was puzzling as to why a crew would be trapped in a shaft in a region where there were no shaft mines, only airshafts and escape hoist shafts. Later that same week, I attended a meeting with a group of geologists and civil engineers who kept incorrectly using mine shafts as a term for drift entries. These misapplications of terms for mine workings can lead to considerable confusion.

Mine openings have exact definitions according to the purpose and orientation of the openings. These definitions are used to denote what appear on mine maps. The symbols and terms have evolved over centuries of mine surveying and map preparation. In order to correctly visualize and interpret what symbols are denoted on a mine map, some basic definitions need to be understood. There are many implications that can be drawn from the appearance and symbols shown on a mine map.

The portrayal of mine workings with surveyed maps has long been an adjunct of mine engineering but in the 1800's with American concepts of property ownership, the technology was advanced. Although some mine regulators might logically believe that it was for safety reasons that the mapping technology developed, in fact, it was for the assignment of royalties. The anthracite fields of Pennsylvania were one of the main contributors to the early US technology because of multiple seams with several ownerships and constant incursions beyond boundaries; this was at a time when there was a heavy demand for this fuel for the industrial revolution along the east coast.

This paper will present some terms that are commonly used in mining and depicted on maps. These terms are from the recently published "Introductory Mining Engineering" by H. L. Hartman and J. M. Mutmansky. Dr. Mutmansky has kindly permitted me to borrow heavily from his text; his generosity is greatly appreciated.

TERMS TO DESCRIBE MINE ACCESS

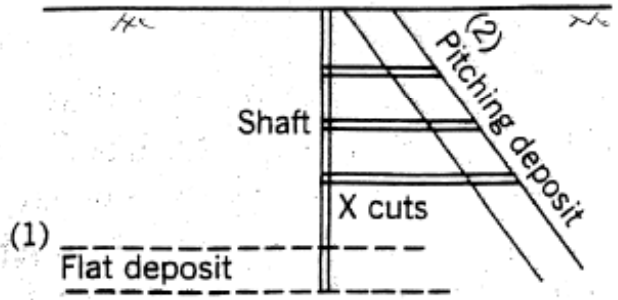
The economic means of access opening to an ore or deposit is usually a function of the orientation of the resource. The access opening can be vertical (shaft), inclined (slope or incline), or nearly horizontal (drift or adit). The means of economic haulage over the life of the mine usually dictates the mode of haulage opening. Vertical or inclined shafts require hoisting equipment at the surface; because mine hoists used steam power into the 1950's, ash deposits can be an indication of the boiler at the surface location. Slopes driven for conveyor belt haulage are driven no steeper than the angle at which backsliding of the mineral occurs on the belt. As drifts are nearly horizontal, belts are economic for materials haulage today. In the past, track and animals were used. There is often some type of processing at the belt head on the surface ranging from screening to full preparation along with extensive storage. This processing is often indicated by waste piles and decrepit structures.

Besides the mineral wastes, other mine wastes from processing and electrical equipment may pose hazardous waste problems. The structures associated with the mine access and processing can also be of historic importance. These factors should be considered with environmental assessments and impact statements in routing new roads.

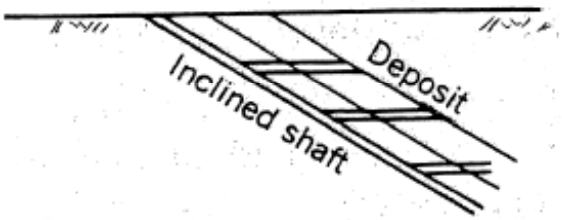
Figure 1 shows these mine access modes and the relative orientation of the mineral. Definitions for these access modes are provided in Table 1 below.

TABLE 1 – Definitions of Access Modes

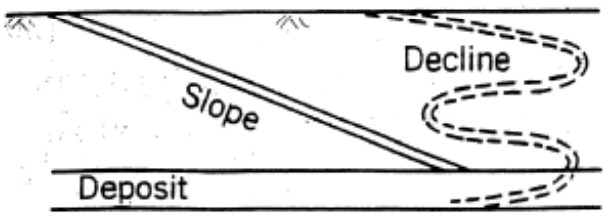
1. *Vertical shaft with hoisting.* For deep horizontal (<30°), vertical, or steeply inclined (>70°) deposits; bad natural conditions; high production; long life.
2. *Inclined shaft with hoisting.* For moderately inclined (30° - 70°) deposit; moderate conditions; low to moderate production and life; shortens horizontal development and allows exploration during sinking.
3. *Slope or decline with haulage* (conveyor or truck). For shallow or medium-depth horizontal deposits; good to moderate conditions; moderate to high production; long life; rope hoisting can be installed and rail haulage can be used; limited to about 12% to 14% with trucks and about 16° with a conveyor (unless special equipment is used).
4. *Drift or adit with haulage* (conveyor, truck, rail, etc.). For shallow outcropping, horizontal deposit or steeply inclined deposit in area of high relief; varied conditions; high production; long life.



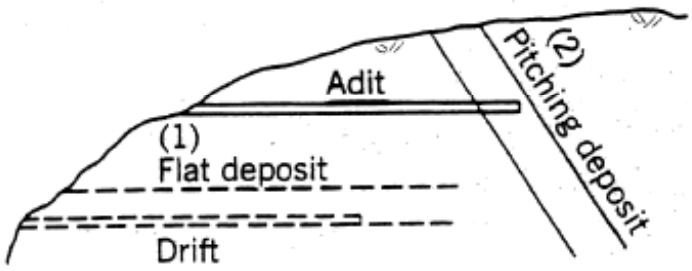
Shaft with hoisting



Inclined shaft with hoisting



Slope or decline with haulage



Adit or drift with haulage

FIGURE 1
MINE ACCESS

MINE MAPPING PROCEDURES

A mine map should show the horizontal controls, property lines, outlines of existing entries and pillars, locations of wells, surface structures, utilities, roads and streams. In addition, all other items as required by regulations, e.g., ventilation devices and other mine workings in proximity. The map is prepared by analyzing survey data.

The survey data are usually reduced to rectangular coordinates as either a state coordinate or mine-local coordinate system. The basic survey reference point within the mine workings is a roof spad. A spad is a tagged point placed in the roof that serves as an instrument station. The roof location is used to avoid disturbance due to heavy traffic of mine haulage.

There are two basic mine maps. There are projection maps and actual workings maps and combinations of these types. Projection maps show with lighter line weights the location of planned mine workings. Because of changed conditions underground, mine projections are often not always achieved. As pillar retreat mining or longwall mining is completed, crosshatching and date lines are used to designate progress on actual mine workings maps. The maximizing of a mineral resource is common within lease terms and so the cross hatching of mined areas implies that economic recovery has been accomplished or that the area is unsafe for further mining.

In recent years, mine mapping has changed into greater use of electronic data gathering and CAD plots. Older maps were compiled by drafters who often had at one time served as underground surveyors. These drafters were capable of data gathering, analysis, and plotting of the data into mine maps.

TERMS TO DESCRIBE MINE OPENINGS

Generally mine openings can be categorized by importance to the overall layout of the mine. Primary openings are the access points as listed previously. These include shafts, slopes, and drift portals. Secondary openings are those within the same level or zone and tertiary openings are crosscuts and ramps to other levels.

A list of terms essential to accurate nomenclature of mine workings is presented in Tables 2 and 3. Some of these terms are the features observed with mine mapping and sometimes they are designated only with symbols.

MINE SYMBOLS

Significant features of a mine are depicted with symbols. Although the symbol may be quite simplistic, the actual feature can be more complicated than the depiction. As an example, Figure 2 shows an overcast, which is a device to allow return air to cross over an intake airway. The actual details in plan and sectional view show the careful construction needed to separate the higher-pressure intake air from the lower pressure return air. The symbol used on a map is basically an 'X'.

Symbols commonly used in mine mapping are provided as Figure 3. Figure 3 and the previous example come from the excellent text by W. Randolph Williams "Mine Mapping and Layout" (Prentice Hall) which is reported to be still in print. Symbols do vary on older maps and legends, if contained on the map, are helpful.

Symbols have been consistent in portraying mine workings. What has changed is the advent of electronic surveying equipment along with the use of CAD to produce mine maps quickly. The arduous task of hand drafting onto reproducible sheets has evolved into the whirring noise of the plotter. Unfortunately, the sterile nature of the CAD plot does not convey the art, skill, and care as shown with previous hand-drawn maps.

TABLE 2. MINE OPENING TERMS
EXCAVATION TERMS

Adit: Main horizontal or near-horizontal underground opening, with single access to the surface

Bell: Funnel-shaped excavation formed at the top of a raise to move bulk material by gravity from a stope to a drawpoint

Bleeder: Exhaust ventilation lateral

Chute: Opening from a drawpoint, utilizing gravity flow to direct bulk material from a bell or orepass to load a conveyance

Crosscut: Tertiary horizontal opening, often connecting drifts, entries, or rooms; oriented perpendicularly to the strike of a pitching deposit; also *breakththrough*

Decline: Secondary inclined opening, driven downward to connect levels, sometimes on the dip of a deposit; also *declined shaft*

Drawpoint: Loading point beneath a stope, utilizing gravity to move bulk material downward and into a conveyance, by a chute or loading machine; also *boxhole*

Drift: Primary or secondary horizontal or near-horizontal opening; oriented parallel to the strike of a pitching deposit

Entry: Secondary horizontal or near-horizontal opening; usually driven in multiples

Finger raise: Vertical or near-vertical opening used to transfer bulk material from a stope to a drawpoint; often an interconnected set of raises

Grizzly: Coarse screening or scalping device that prevents oversized bulk material from entering a material transfer system; constructed of rails, bars, beams, etc.

Haulageway: Horizontal opening used primarily for materials handling

Incline: Secondary inclined opening, driven upward to connect levels, sometimes on the dip of a deposit; also *inclined shaft*

Lateral: Secondary or tertiary horizontal opening, often parallel or at an angle to a haulageway, usually to provide ventilation or some auxiliary service

Level: System of horizontal openings connected to a shaft; constitutes an operating horizon of a mine

Loading pocket: Transfer point at a shaft where bulk material is loaded by bin, hopper, and chute into a skip

Longwall: Horizontal exploitation opening several hundred feet (meters) in length, usually in a tabular deposit

Manway: Compartment of a raise or a vertical or near-vertical opening intended for personnel travel between two levels

Orepass: Vertical or near-vertical opening through which bulk material flows by gravity

Portal: Opening or connection to the surface from an underground excavation

Raise: Secondary or tertiary vertical or near-vertical opening; driven upward from one level to another

Ramp: Secondary or tertiary inclined opening, driven to connect levels, usually in a downward direction, and used for haulage

Room: Horizontal exploitation opening, usually in a bedded deposit

Shaft: Primary vertical or near-vertical opening, connecting the surface with underground workings; also *vertical shaft*

Slope: Primary inclined opening, usually a shaft, connecting the surface with underground workings

Slot: Narrow vertical or inclined opening excavated in a deposit at the end of a stope to provide a bench face

Stope: Large exploitation opening, usually inclined or vertical, but may also be horizontal

Sublevel: Secondary or intermediate level between main levels or horizons, usually close to the exploitation area

Transfer point: Location in the materials-handling system, either haulage or hoisting, where bulk material is transferred between conveyances

Tunnel: Main horizontal or near-horizontal opening with access to the surface at both ends

Undercut: Low horizontal opening excavated under a portion of a deposit, usually a stope, to induce breakage and caving of the deposit; also a narrow *kerf* cut in the face of a mineral deposit to facilitate breakage

Winze: Secondary or tertiary vertical or near-vertical opening, driven downward from one level to another

TABLE 3. GENERAL MINING TERMS

Breast: Advancing in a near-horizontal direction; also the working face of an opening (customarily used to modify *stoping* or *mining*)

Dip: Angle of inclination of a deposit, measured from the horizontal; also *pitch* or *attitude*

Floor: Bottom or underlying surface of an underground excavation

Footwall: Wall rock under the deposit

Gob: Broken, caved, and mined-out portion of the deposit

Hanging wall: Wall rock above a deposit

Inby: Toward the working face, away from the mine entrance

Outby: Away from the working face, toward the entrance

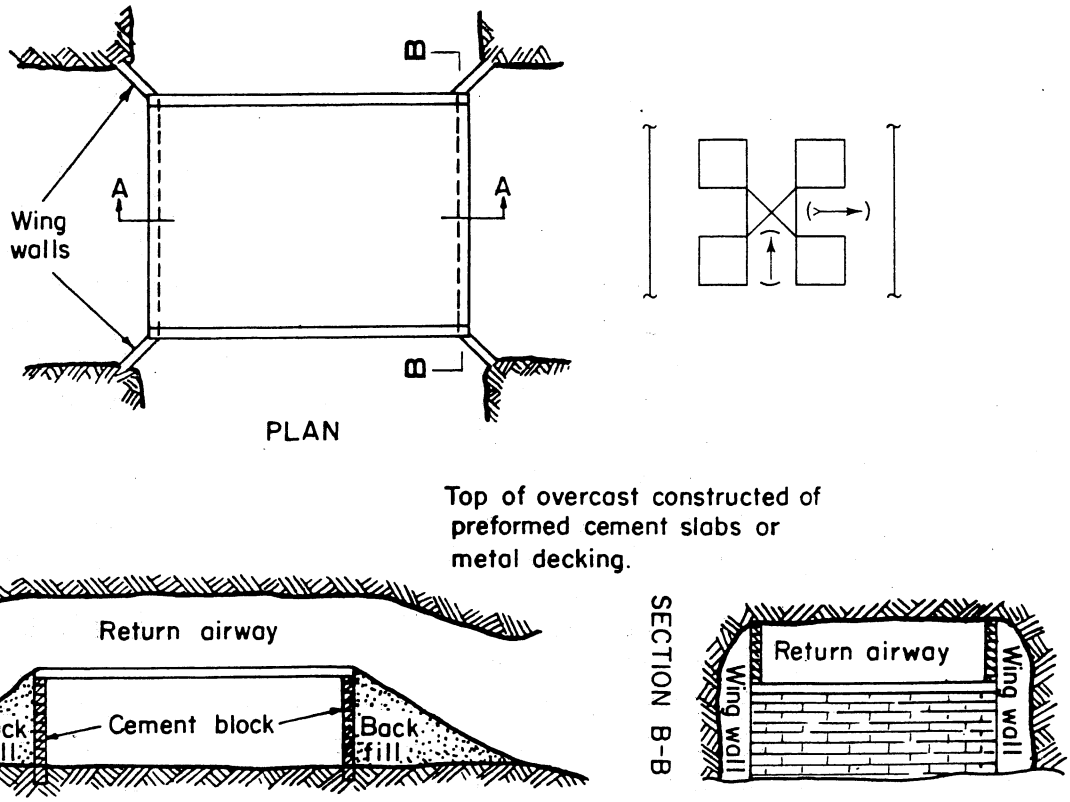
Overhand: Advancing in an upward direction (customarily used to modify *stoping* or *mining*)

Pillar: Unmined portion of the deposit, providing support to the roof or hanging wall

Rib: Sidewall of an excavation; also *rib pillar*

Roof: Back, top, or overlying surface of an excavation

Underhand: Advancing in a downward direction (customarily used to modify *stoping* or *mining*)



(COURTESY OF MSHA)

HIGH CAPACITY OVERCAST

FIGURE 2
OVERCAST SYMBOL

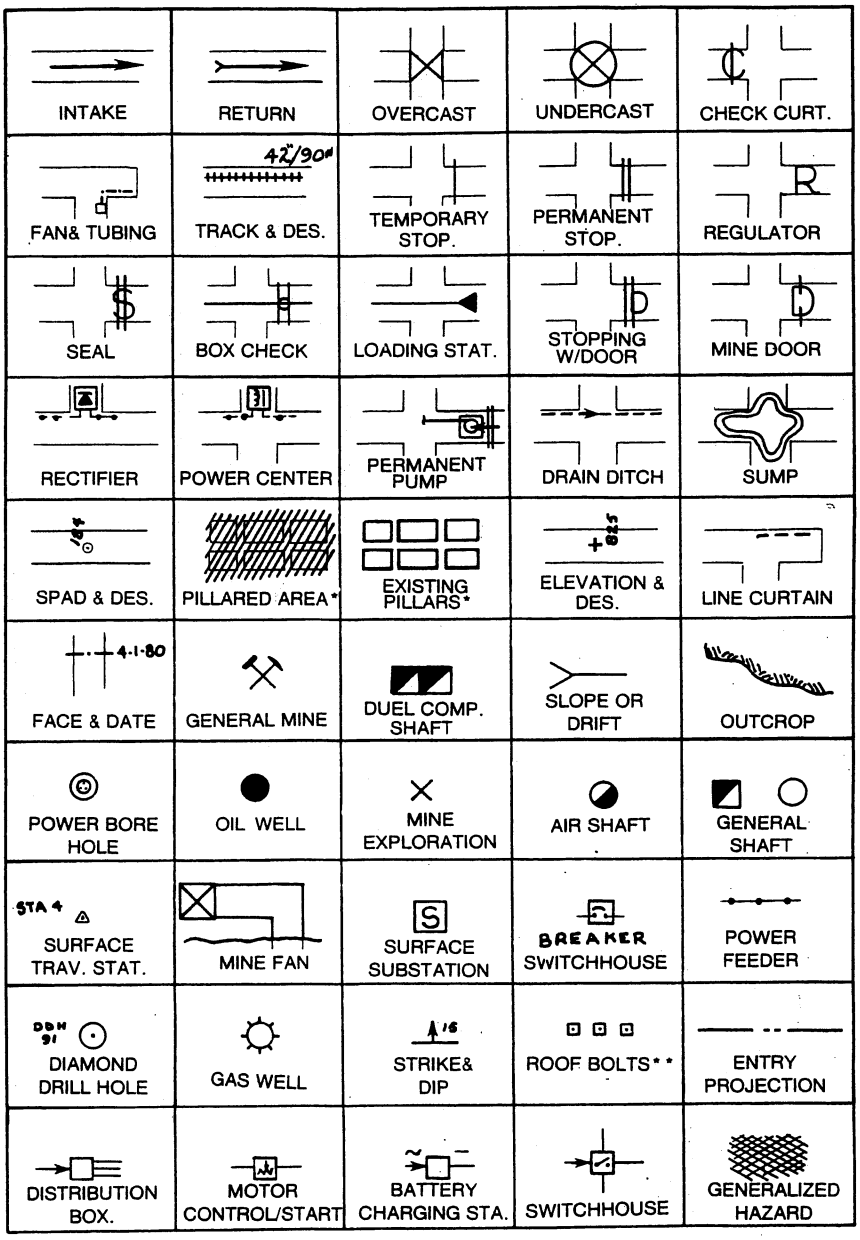


FIGURE 3
COMMON MINE MAP SYMBOLS

From Williams, "Mine Mapping and Layout"

SUMMARY

Terms used to describe mine workings have defined meanings. These specific features are conveyed on a mine map via lines and symbols. These surveying and mapping procedures have evolved through several centuries into the electronic acquisition and computer plotted mine maps of today.